Research Article

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Electrodeposition of Transition Metal Influenced Magnetic Alloys and Its Microstructural Properties

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ABSTRACT

Magnetic alloy coatings exhibit admirable magnetic properties and corrosion resistance. However, their applications are restricted due to a complex preparation process and high costs. In the present work, an attempt has been made to prepare cobalt alloys with other transition metals through a simple electro-deposition method. In order to attain cobalt-rich alloys, appropriate chloride salts were chosen as precursors. After the deposition process, the deposited alloys were carried out for microstructural characterization. EDAX pattern of the prepared alloys confirms the presence of relevant elements at a higher percentage, morphology properties of the films confirm the even and crack-free coatings. The corrosion resistance of the prepared alloys was investigated in an acidic medium, and it was found to be better when compared with the empty substrate. The Electrodeposition process has great potential in producing alloys with better purity than other methods.

Keywords: Cobalt alloys; Corrosion resistance; Electrodeposition; Magnetic alloys.

1. INTRODUCTION

Electrodeposited Co, Ni metals, and its alloys were frequently reported in past decades because of its wide range of applications (Sundaram *et al.* 2011; Landolt, 2002; Manimaran and Navaneetha, 2015). Even though cobalt has better magnetic properties than nickel, electrodeposited Cobaltare expensive than Nickel deposits because of Cobalt and its precursor cost. Hence cobalt has been alloyed with many combinations of elements, especially with nickel and other transition metals (Prabhu Ganesan *et al.* 2006; Baldwin and Smith, 1996). When cobalt has been alloyed with any transition metal group element, it offers better physical properties such as magnetic properties, mechanical stability, thermal stability, and electrochemical performance (Baskar *et al.* 2014; Mohan *et al.* 2016). In the past few years, Co-Ni alloys have been reported with tungsten, Vanadium, Manganese,Tin, and other expensive transition metals (Kannan and Kokila, 2015; Asutosh Kumar Pandey, 2013; DimitraVemardou *et al.* 2014; Rajkumar *et al.* 2019; Xu-Ming Sun *et al.* 2011; Kwang Pyo Chae, 2006). Over these zinc and cadmium were a cost-effective alloy combination that offers good soft magnetic and corrosion resistance. In the present work, a comparative approach on Zinc and cadmium incorporated Co-Ni alloy was investigated through electrodeposition technique. To achieve Co, Ni-rich alloy, appropriate chloride salt has been chosen as precursors (Ezhil Inban Manimaran *et al.* 2017). To optimize the ideal deposition time, the thickness of the alloy was studied using weigh balance method. Elemental constituents and morphological properties of the prepared alloy were studied and confirmed using EDAX pattern and FE-SEM micrographs, respectively. The corrosion behavior of the alloys was investigated using the weight loss method.

2. EXPERIMENTAL METHOD

An electrolyte composed of chosen chlorides was dissolved in DI water by adding boric acid as a complexing agent. The bath composition used for the electrolyte has been given in table.1 and its pH has been controlled and maintained as 5. Both cadmium and zinc incorporated alloys have been electrodeposited on copper plates with the dimension of 1.5 X 5 Cm (cathode), and it was pre-cleaned through the acid dipping process. Nickel rod with the same dimension has been used as Anode in the deposition process. Both alloys were electrodeposited at the optimized current density of 10 mA/cm^2. After the deposition process, electroplated copper substrates are carefully removed from the bath and washed with DI water.

3. RESULT & DISCUSSION

The thickness of the electroplated alloys was monitored with the help of the weighing balance method. Fig.1 shows the thickness variation of both alloys, and it confirms that when the deposition time is increased thickness of both alloys was linearly increased. As the deposition time increases to 40 minutes, films found to be having powder deposition, which tends to be peel off.

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This is due to the internal stress experienced in the film, and it was immensely increased for the film deposited at 40 minutes. Hence the alloys electrodeposited at 10 mA/Cm^2 for 30 minutes were carried out for further characterization.

Table 1. Bath Composition Used for Electrodeposition

Alloys	Concentration	Ingredients in Bath
Co-Ni-Zn	0.2M	Cobalt Chloride Nickel chloride Boric acid
	0.1M	Zinc chloride Potassium chloride
Co-Ni-Cd	0.2M	Cobalt Chloride Nickel chloride Boric acid
	0.02M	Cadmium chloride Ammonium chloride

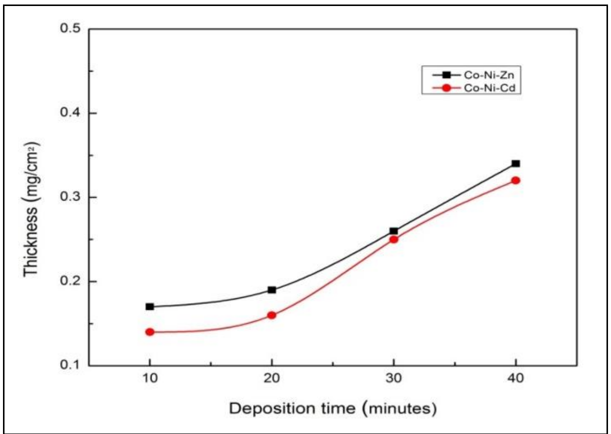

Fig .1: Thickness Deviation of Electrodeposited Alloys

Structural properties of the electrodeposited alloys were studied using X-ray diffractogram, and it is shown in Fig 2. Structural properties confirm good crystalline nature in the samples; this confirms that all the films deposited on copper plates have good crystallinity by nature. Cobalt and nickel diffraction planes were retained in both alloys with slightly varied intensity. However, the presence (102) (011) and (101) planes in the samples represent the cadmium and zinc elements in the alloy. The Crystalline size of the samples was calculated using the Scherer formula, which was found to be in the nanometer range (16 and 18 nm).

EDAX pattern of the electrodeposited Co-Ni-Cd and Co-Ni-Zn alloys was shown in Fig. 3(a,b). It confirms the presence of cobalt and nickel elements, along with zinc and cadmium. In both alloys, cobalt and nickel deposition (30-50 %) was reasonably good compared with other alloys. Morphological properties of the alloys were investigated using FE-SEM micrographs (Fig 4(a-b)), which reveal uniform deposition in both alloys. But in Cadmium incorporated alloys the surface was found to be having an under developing dendritic structures. It is due to the deposition of cadmium content at a high percentage.

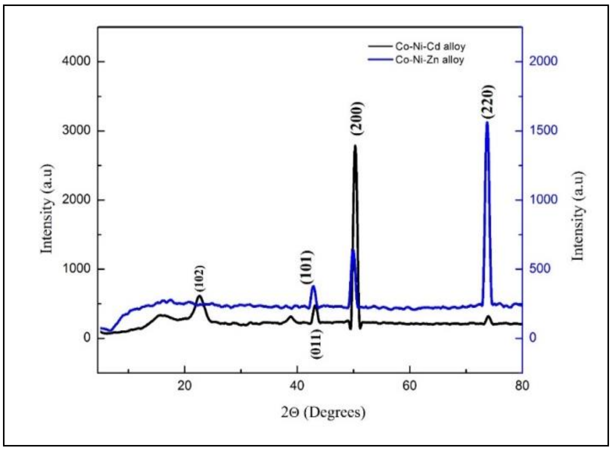

Fig. 2: X-ray Diffractogram of Electrodeposited Alloys

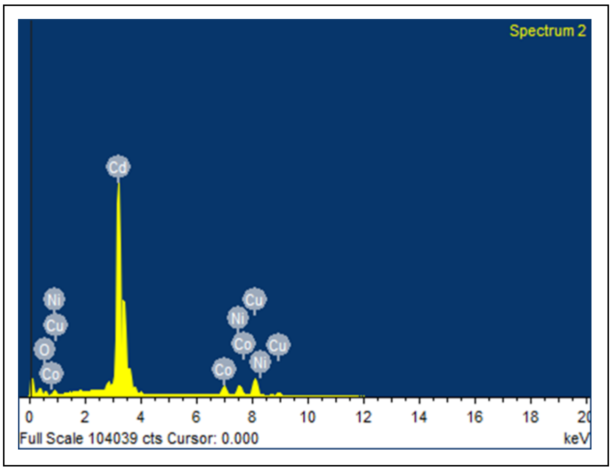

Fig. 3 (a): EDAX Pattern of Co-Ni- Cd Alloy Electrodeposited at Optimized Deposition Parameters

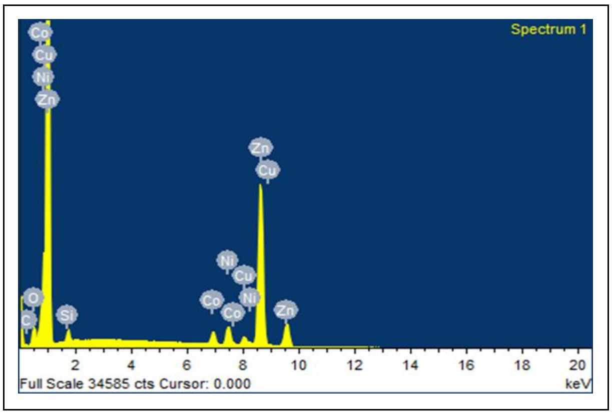

Fig. 3(b): EDAX Pattern of Co-Ni- Zn Alloy Electrodeposited at Optimized Deposition Parameters

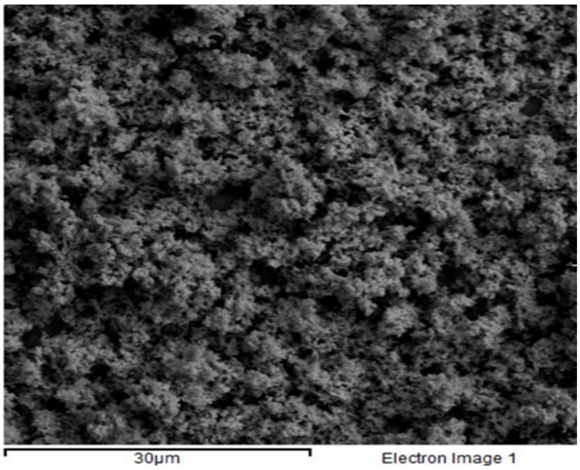

Fig. 4 (a): FE-SEM Micrograph of Co-Ni- Cd Alloy Electrodeposited at Optimized Deposition Parameters

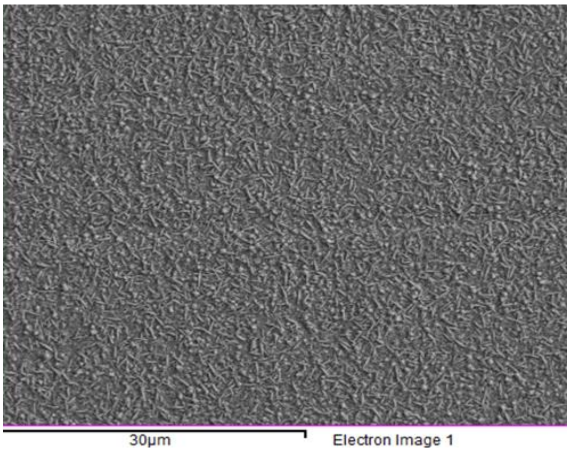

Fig. 4(b): FE-SEM Micrograph of Co-Ni- Zn Alloy Electrodeposited at Optimized Deposition Parameters

The corrosion behavior of the prepared alloys was investigated in an acidic medium (or) bath; it is composed of diluted Hydrochloric acid. The corrosion properties of the alloys were presented in Table 2. From this, it is confirmed that both alloys exhibit far better corrosion properties than expected compared to the empty substrate. The presence of zinc and cadmium strongly enhances the corrosion properties and it was equally supported by Nickel deposits in the alloys.

Table 2. Corrosion Behavior of the Electrodeposited Samples

Samples	Corrosion Rate (mpy)
Copper substrate	730
Co-Ni-Cd	67
Co-Ni-Zn	62

4. CONCLUSION

Transition metals like cadmium and zinc have been incorporated with magnetic elements like Cobalt nickel and prepared as alloy using electrodeposition method. Microstructural and corrosion properties of the prepared alloys were investigated. Microstructural properties reveal the presence of cobalt nickel, zinc and cadmium elements along with substrate peak. FE-SEM micrographs confirm even, and crack-free coatings, and the zinc incorporated alloys exhibit under-developing dendritic structures in the alloys. Magnetic properties of the alloys confirm the soft ferromagnetic nature in both alloys. Corrosion properties were reasonably good, and it was immensely dependent on the incorporated (Zn, Cd) elements in the alloys. In summary, the electrodeposited alloys which exhibit better corrosion resistance and soft magnetic nature can be used for soft magnetic sensors and anti-corrosive coatings.

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